VOL. VI, PP. 23-34, PLS. 1-3 MARCH 17, 1894

THE

NATIONAL GEOGRAPHIC MAGAZINE

SHAWANGUNK MOUNTAIN

N. H. DARTON

UNITED STATES GEOLOGICAL SURVEY

WASHINGTON

PUBLISHED BY THE NATIONAL GEOGRAPHIC SOCIETY

REPRINT

Price 25 cents.

XUM

STEREOGRAM
OF THE
SHAWANGUNK MOUNTAIN
IN
ULSTER CO. NEW YORK
BY
N.H. DARTON U.S. Geol. Survey

Scale

VERTICAL. 0 500 1000 3000 6000 FEET
HORIZONTAL ½ 1 2 4 MILES. } = 1 : 3½

(The Base is at Sea Level.)

XUM

VOL. VI, PP. 23-34, PLS. 1-3 MARCH 17, 1894

THE

NATIONAL GEOGRAPHIC MAGAZINE

SHAWANGUNK MOUNTAIN*

BY

N. H. DARTON

UNITED STATES GEOLOGICAL SURVEY

Shawangunk† mountain is a prominent range lying between Hudson river and the southern Catskills, in Ulster county, New York. To the eastward it rises from the Wallkill valley in steep inclines, surmounted by a high escarpment; to the westward it slopes to the Rondout valley. Along its axis it rises gradually south of Rosendale, and finally attains an elevation of 2,200 feet and a width of five miles. It continues to the southward, with somewhat decreased height and width, through New Jersey and Pennsylvania, where it is known as Kittatinny mountain, and gives rise to the Delaware, Lehigh and Susquehanna water-gaps.

The well known summer resorts of lake Mohonk and lake Minnewaska are on the summit of Shawangunk mountain, in Ulster county, so that the region has become familiar to a large number of visitors. Unfortunately, however, no description of its geology has ever been published and the meagre references in the report of Mather‡ throw but little light on the subject.

During the autumns of the past two years I have had occasion to spend a few days on the mountain to determine the salient

* Published by permission of Professor James Hall, State Geologist, in advance of the Annual Report of the Geological Survey of New York.

† Pronounced "Shongum," according to the residents of the region.

‡ Geology of New York, Report on the First Geological District, 1843.

features of its geology in Ulster county, and they were found to be of great interest. In this article there is presented a brief summary of the results of my observations, but in a report on the geology of Ulster county, now in preparation, there will be a somewhat more detailed description of the region.

The structure of Shawangunk mountain in Ulster county is a particularly interesting illustration of close relation of rock texture to topography, for the presence of the mountain and its form are directly dependent on the structure of a relatively thin sheet of hard rock. In the accompanying stereogram (plate 1) an attempt has been made to represent its physiographic character, and the structure is shown in the cross-section at the ends of blocks into which the supposed model is divided. The mountain consists of a widely extended sheet of Shawangunk grit lying on soft Hudson shales. This sheet lies in a gently westward-dipping monocline which is corrugated by a series of gentle longitudinal flexures. To the westward it dips beneath shales and limestones of the succeeding formations in the Rondout valley; to the eastward it terminates in long lines of high precipices which surmount steep slopes of Hudson shales. Its anticlinals give rise to high ridges and wide plateaus; its synclinals constitute in greater part the intervening depressions. In several portions of the mountain the grit has been eroded off the crests of the anticlinals and the underlying slates are bared. This is the case in a wide area southeast of Ellenville, in a long strip extending from near lake Mohonk nearly to Rosendale, in a small area east of Wawarsing, and in the top of the mountain north of lake Minnewaska. Mather has suggested that the great cliffs of the region are due to faults, but I find this is not the case. Only one fault was found, and this was a small overthrust in the Rosendale region. There are many slight faults of a few inches or feet, but they appear to be entirely in the grit.

The surface of Shawangunk mountain is nearly everywhere very rugged, and cliffs and rocky slopes abound. These consist of snow-white grits, more or less mantled with dark lichens, and are remarkably picturesque. There are many cataracts, several beautiful rock-bound lakes, and widely extended views of the Catskills to the westward and the Hudson valley to the eastward. The ruggedness is due to the exceptional hardness of the grits, the softness of the underlying shales, and a tendency to vertical jointing which gives rise to cliffs and clefts.

There are low lines of cliffs all over the surface of the mountain, especially to the southward, but along the eastern face, where the grit is being continually undermined by erosion of the slate, they are of great prominence, in some cases having a nearly vertical height of two hundred feet and extending continuously for many miles. The "points" are projections or promontories of the eastern edge of the grit beyond the general crest line, due to a less degree of recession. Buntico point, Paltz point, Gertrude nose and Sams point are the most prominent of these, but there are many others of minor importance. The cliffs on the surface of the ranges are of various heights and lengths, and rise along joint cracks. They face in various directions, but a north-and-south trend is predominant. They are usually in irregular, discontinuous steps on the slopes and face each other and enclose depressions of various sizes on the plateaus.

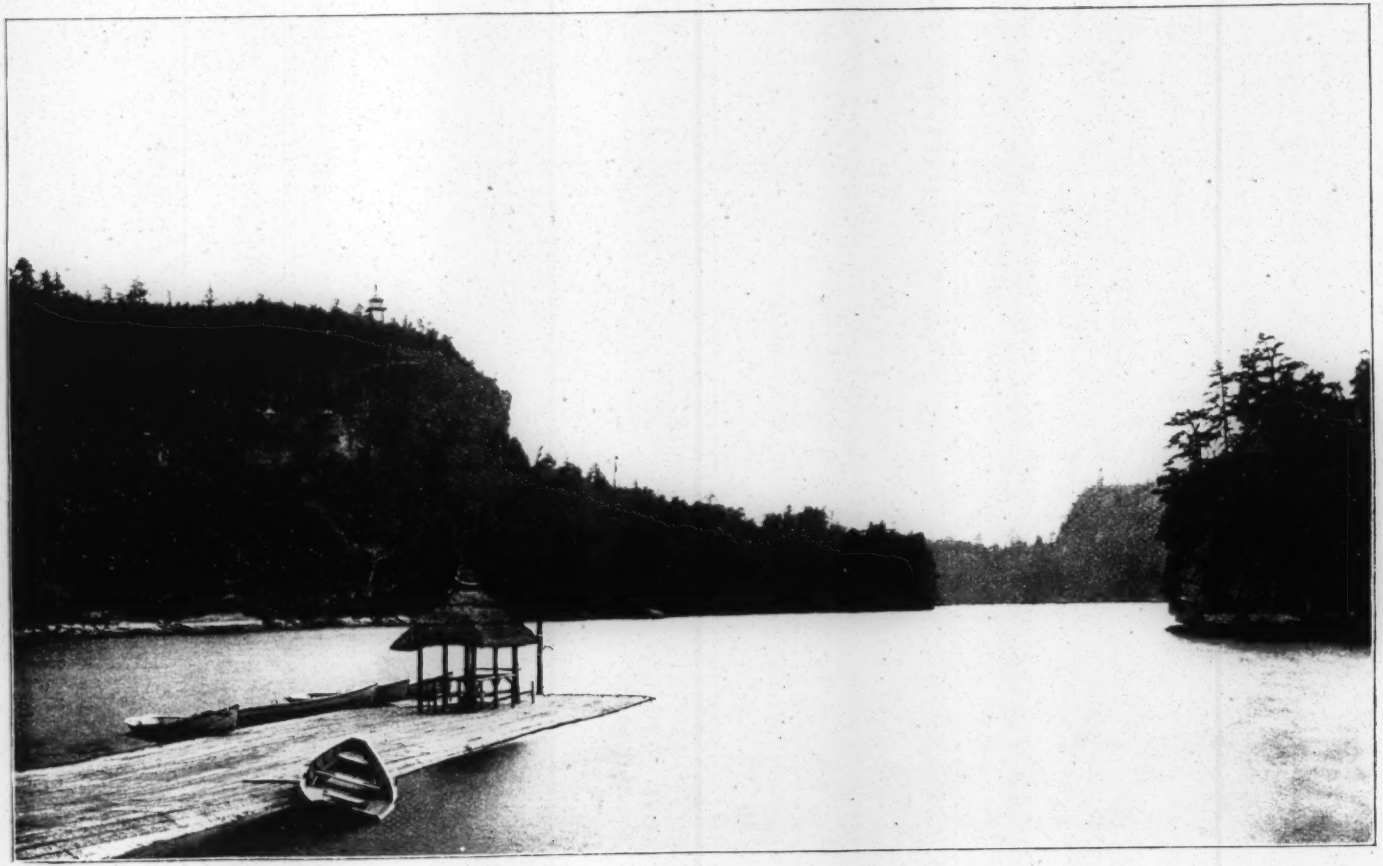
The lakes for which the mountain is famous lie in basins of moderate depth and are all near the top of the range. They are nearly surrounded by cliffs of Shawangunk grit of greater or less height, which add greatly to their beauty. The grit is mainly a messive white or gray quartzite or conglomerate, averaging 250 to 300 feet thick. The proportion of pebbles is large but variable, many beds being fine. The pebbles and grains are quartz, and the matrix is siliceous. The conglomerate is the famous Esopus millstone, and has been largely quarried for two centuries.

The relations of the Shawangunk grit to the Hudson shale in the Shawangunk mountain region is one of slight but persistent unconformity. The coarse grit lies directly on the eroded surface of the shales. This erosion has truncated low arches of the slate, but has channelled its surface only slightly. Exposures of the relations are everywhere abundant. One of the best instances is along the road from Minnewaska to New Paltz, two miles south of lake Mohonk. Here along the mountain slope a very low arch of the grit is seen surmounting a truncated arch of shales of materially steeper dip. Diversity of dip is seen at every locality, varying from very slight to 10°, but several points were observed where it was hardly perceptible.

The corrugations in the general monocline of the mountain are a series of anticlinals and synclinals which traverse the range diagonally from north-northeast to south-southwest and begin in succession from northeast to southwest, their axes rising gradu-

ally to the southward. Beginning at the northern end of the range the principal feature is the anticlinal which brings up the cement between Rosendale and Whiteport. South of Rondout creek, opposite Rosendale, the upward pitch of this flexure increases rapidly, and the Shawangunk grit soon rises into a ridge of considerable altitude. In a short distance from the creek the grits are eroded from the crown of the arch, and to the southward the underlying shales constitute a series of high but rounded hills extending along the center of the mountain. The occurrence of these high hills of soft rock is a striking feature, and they give a unique character to this portion of the mountain. Their presence is due to the former protection of the arch of Shawangunk grit by which they were originally covered. The grit in the flanks of this arch extends down the slopes of the mountain, where it dips beneath overlying formations in the valley on the western side and extends nearly or quite to the base on the eastern side. One mile and a half south of Rosendale the range has the structure shown in the first section on the stereogram. It will be seen that the sheet of grit lying along the eastern slope of the mountain is considerably corrugated. This corrugation consists in the main of a western limb dipping more or less steeply eastward, and a shallow synclinal. In one portion of the ridge, there is a very abrupt anticlinal crumple in this synclinal which extends but a short distance in either direction and then flattens out into the general flexure. There is also a fault which extends from the Rosendale cement region. It gives rise to a sharp ridge which continues to the first road across the mountain, beyond which it dies out. Along the eastern face of the northeastern range of the mountain the dips are in greater part gently to the westward. Along the railroad they are 20°, and this is the average for some distance. On the first road across the mountain the dips are 60°, but this steep dip soon gives place to inclinations of not over 10°, and toward the southern end of the ridge the synclinal dies out, leaving a gentle dip eastward. This grit area lying along the eastern slope of the mountain terminates abruptly southward in a fine line of cliffs which, owing to the upward pitch of the bed in this direction, are of great elevation. This is Buntico point, one of the most prominent topographic features in the region. Its character is shown in the stereogram.

South of Buntico point the eastern crest and summit of Shawan-



LAKE MOHONK LOOKING SOUTHWARD.

gunk mountain consists of a great mass of Hudson shales, which are being rapidly and deeply eroded. They extend southward nearly to lake Mohonk, where the crest of the anticlinal is occupied by grit for some distance. The grit in the western limb of the anticlinal on the northern end of the mountain lies part way down the western slope and does not attain the prominence that it has in the area terminating in Buntico point. It constitutes a monoclinal ridge, with a line of cliffs along its eastern edge, above which the hills of Hudson shales rise several hundred feet. To the westward the Shawangunk grit dips beneath overlying formations in the synclinal valley of Coxingkill. On the opposite side of this valley, at High Falls, there rises one of the principal anticlinals of Shawangunk mountain, which soon brings up Shawangunk grit in the low ridge on which the village is built. This ridge gradually increases in width and altitude southward, and near the line of the third section on the stereogram its crest is nearly as high as the ridge eastward, from which it is separated by the synclinal valley of the Coxingkill.

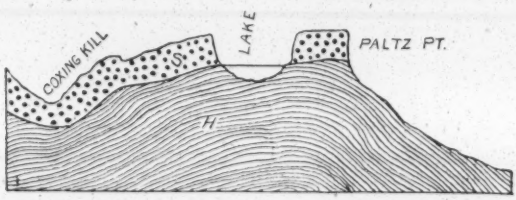


FIGURE 1.—*Cross-Section of eastern Ridges of Shawangunk Mountain through Lake Mohonk, looking northward (S, Shawangunk Grit; H, Hudson Shale). Vertical scale exaggerated.*

South of Alligerville the mountain widens rapidly as flexure after flexure brings up the Shawangunk grit from the northwestward. The western ridge rises gradually on the upward pitch of the axis of the flexure, and finally becomes the highest part of the mountain east of Ellenville. Southwest of lake Mohonk there are five of these flexures, together with various small undulations, with a creek in each synclinal. Lake Minnewaska is in the crown of the anticlinal which rises at High Falls, and lake Awosting is on the western slope of the same flexure.

These lakes are all situated near the eastern side of the mountain and about 150 feet below the crest. They are similar in relation and originated under almost the same conditions. Lake Mohonk occupies a north-and-south cleft in the crown of the

anticlinal which rises at Rosendale. The structure of lake Mohonk is shown in figure 1.

The lake basin is in Hudson shales, but it is bordered on the east and west by high cliffs of Shawangunk grit. To the south there is a gap in the front of the mountain through which the shales extend to the lake. The top of these shales is a few feet above the surface of the lake at its southeastern end, but the pitch carries them a few feet below the water surface toward the north and west.

On plate 2 are shown some features of lake Mohonk.

This view is looking to the southward and out of the gap in the eastern front of the mountain through which the Hudson shales extend to the lake. On the left is Paltz point, and to the right, in the distance, is Cope point, a projection of the southern extension of the eastern front of the mountain.

East of the lake there is a thick mass of grit, which lies along the crest of the anticlinal. It begins a short distance northward and is terminated by very abrupt cliffs in Paltz point, near the southern end of the lake. The character and relations of this "point" are represented in the stereogram.

At the head of the lake and the base of the southern end of the mass of grit in Paltz point the Hudson shales constitute a small plateau which surmounts the long eastern slope of the mountain. There is no cross-drainage way at the base of the cliffs and the reason for the abrupt termination of this point is obscure.

The grit dips gently west-northwestward along the western side of Paltz point and very slightly eastward in its easternmost part. Northeast of the lake the dip is at a low angle to the westward, but there are several slight undulations. There is everywhere a pronounced pitch northwestward. Owing to the westerly dip the grits in the Paltz point ridge are somewhat lower just north of the lake than elsewhere. It will be seen from these statements that the lake lies slightly west of the center of the arch of the anticlinal, and all the dips along its shores are northwestward, although at very low angles. The degree of dip rapidly increases down the western slope of the mountain into the synclinal valley of Coxingkill.

The outlet of lake Mohonk is to the northward by a branch of Coxingkill. This branch flows through a slight depression separating the Paltz point range from the main mountain mass, and then obliquely down the flank of the anticlinal.

South of Paltz point the eastern front of the mountain presents a nearly unbroken line of high cliffs for many miles along or near the crest of the anticline. The nature of a portion of this escarpment is shown in plate 3

Two miles south of lake Mohonk there is a slight depression in the crest line through which the road to lake Minnewaska passes, and there are several other depressions of less amount. Millbrook mountain is the culminating feature of this portion of the range, beyond which its front is somewhat more irregular in contour.

Lake Minnewaska is similar to lake Mohonk in appearance, but it is somewhat larger. It was not ascertained whether its basin extends into the Hudson shales, for there is a continuous rim of grit surrounding it. As a very great thickness of grit is exposed above the water level in this vicinity, it seems probable that the bottom of the lake is in or very near the shales. This probability is increased somewhat by the presence of the steep

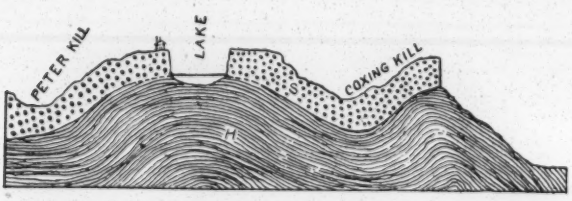


FIGURE 2.—*Cross-Section of the eastern Ridges of Shawangunk Mountain through Lake Minnewaska, looking northward (S, Shawangunk grit; H, Hudson shales).*

cliffs and the width of the valley or cleft in which the lake lies. In figure 2 there are shown the principal structural features at this locality.

The cliffs which extend along the eastern side of the lake are very high and precipitous. As at lake Mohonk, the rocks are greatly fissured and are traversed by many deep wide clefts. The dips are gently anticlinal about the lake, which is on the axis of the flexure but they increase in amount to the east and west. The lake empties to the southward through a wide gap, into the synclinal valley of the Coxingkill, and it may be regarded as the headwaters of this stream.

A mile northeast of the lake the anticlinal on which the lake is situated is crossed by the road to Port Hixon, and in the

vicinity of the road the grit has been removed from the crown of the arch for some distance. The road crosses the ridge in a gap on the Hudson shales, and the edges of the grit give rise to high cliffs on either side. Down the slope aways, the grit outcrops on the flank of the arch, but the slate extends along the upper slopes of the mountain for some distance, especially on the east side. The occurrence of the slate in this inlying area is a very striking feature, and the reason for the removal of the grit at this locality is not clear.

South of lake Minnewaska the front of the ridge trends southwestward some distance, and the Coxingkill anticlinal and the anticlinal next west, pass out to the south. There is a prominent "point" in this vicinity known as Gertrude nose, which is due to a deep incision in the front of the mountain made by a small branch of the Wallkill. This stream heads on the plateau south of the lake, passes over the edge of the grit in a series of falls, and has cut a deep gorge into the Hudson shales below.

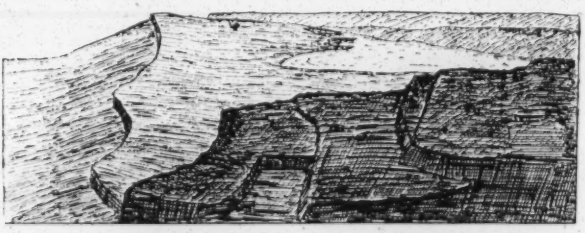


FIGURE 3.—*Lake Awosting from the East-northeast, Sams Point in the Distance.*

Lake Awosting is the largest lake of the series, and has a length of about a mile. It is surrounded in greater part by low cliffs and rocky slopes, but near its eastern end there is a line of very high cliffs which extend in from the crest of the mountain eastward and constitutes a high, west-sloping plateau northeast of the lake. In figure 3 there is given a view of this lake based on kodac photographs.

The basin of the lake does not appear to be in Hudson shales, although possibly they underlie its deeper portions. The grit dips gently westward along the lake and this dip continues over a wide area of surrounding region. On the west there is a long slope to the main Peterkill valley, which extends from a low cliff along the lake. The outlet of the lake is by a fork of the

EASTERN FACE OF SHAWANGUNK MOUNTAIN LOOKING SOUTHEASTWARD.

Peterkill which flows along the west-sloping grits for half a mile, and then in high falls over the grit into the kill. East of the confluence there is a narrow depression known as Dark hole, which extends southeastward up the slope of the mountain. It is rimmed by moderately high cliffs of west-dipping grit and was cut by a stream which empties into the Peterkill. On the southern side of Dark hole is the high plateau of which the eastern front constitutes the cliffs at the southeastern end of lake Awosting.

The Peterkill valley from beginning to end extends along the western flank of the anticlinal on which lake Minnewaska is situated, and has a cliff of west-dipping grit on its western side and slopes of grit on its eastern side. Four miles below lake Awosting the kill passes over Awosting falls and then over a series of cascades, aggregating in all a fall of over 240 feet approximately. In Awosting falls there is a clear fall of sixty-odd feet. They are a mile north of lake Minnewaska. In the gorge below the several falls there are high cliffs of grit for some distance, but owing to considerable pitch northward or down stream and a thickness of grit somewhat over 200 feet, the kill has not cut through to the Hudson shales.

South of lake Awosting there are two small, shallow ponds on the summit of the mountain. Mud pond, at the head of Fly brook, the principal fork of the Peterkill, is one, and lake Maratanza is the other. Lake Maratanza empties eastward by a branch of the Wallkill which pitches over the edge of the grit on the crest of the mountain, in a great fall into a deep gulf of Hudson shales. The locality is known as Verkeerder falls.

Between Gertrude nose and Sams point the crest of the mountain is very high, but for some distance the edge of the grit is broken into great terraces and there is a sloping bench of Hudson shales of some width at the base. Several branches of Wallkill drainage head in the crest of the mountain in this region and pass over the edge of the grit in falls of which the above-mentioned Verkeerder falls are the most noteworthy.

In this region the mountain narrows and some of the flexures pass out to the southward. This narrowing is due to recession of the edge of the sheet of the Shawangunk grit, which is closely related to the upward pitch of the flexures. This pitch increases the height of the mountain southward, but with increased height

there is a corresponding increase of erosion in the soft underlying shales, which beyond certain limits causes rapid recession. This is illustrated by Sams point, where the maximum altitude of 2,240 feet is attained. The "point" is a narrowing extension of the grit along the axis of a very flat synclinal, which finally terminates in a high narrow cliff presented southward. From the wide anticlinal area to the west the grit has been eroded and the Hudson shales occupy the surface in a group of very high hills. These hills are surrounded by cliffs of the grit which on the eastern side rise somewhat above their summits, on the northern are about even with their higher summits, and on the western lie along their flanks. Originally the grit area in this region and southward was as wide as it is now at lake Mohonk, but owing to the greater height to which the northern pitch of the flexures carried the grit, it was here more rapidly and widely undermined and removed. It is the grit on the western limb of the anticlinal that lies on the western flanks of the shale hills, constituting a monoclinal ridge of considerable prominence which extends from Ellenville far southward into Pennsylvania. This monoclinal mountain consists of a single-crested ridge of the Shawangunk grit, with a long slope up the dip from the valley westward, which terminates in an east-facing cliff of grit surmounting long rolling slopes of shale on the eastern side of the mountain. Its structure near the southern edge of Ulster county is shown in the bottom section on the stereogram, and this is typical for the greater part of its course. In the valley westward there is a succession of formations overlying the grit, as shown on the left of the sections in plate 1. They are the Clinton red shales, Salina water lime, Helderberg limestone, Oriskany sandstone, Esopus shales, Onondaga limestones, and a great mass of Devonian shales and sandstones which extend into the Catskills. The dips along the western slope of the mountain are low north of Wawarsing, but they rapidly increase southward to an average of about 60° in the vicinity of Ellenville. In this region of steep dips the streams flowing down the steep western slope have cut deep gorges, which extend through the grit into the underlying shales. The two streams south of Ellenville are exaggerated examples of this, and they have been largely instrumental in baring the Hudson shales on the anticlinal area behind Sams point. The two streams just north of Ellenville also cut into the shales, but they are very

small and have only formed narrow gorges. Opposite Napanoch is a small creek which has cut a deep gorge into the shales, and in the higher part of the slope has bared the grit from an area of considerable size, which is surrounded by high cliffs. The stream opposite Wawarsing has cut a gorge and removed an area of the grit on the upper slopes of the mountain, but does not cut through to the shale. The head of this depression extends into the head of the depression opposite Napanoch, and both are surmounted on the east by a continuous line of high cliffs. The stream which flows out of the mountain at Port Hixon is larger than the others and has cut a deep, wide gorge; but owing to the lower dip of the grit it does not appear to have cut through to the shales to any great extent. No shales were observed in place in the depression, but a small amount of shale débris was noticed at one point. Everywhere along the steep slopes there are clefts in the grit, some of which appear to extend down to the shales. One of these is the "Ice cave," a locality which is widely famous in the region. It is high in the slope, about two miles east-northeast of Ellenville. Ice and snow remain in it in greater or less amount, and in some seasons they are preserved entirely through the summer and autumn. In the vicinity there is also an old copper mine from which large supplies of fine quartz crystals were obtained some years ago. The top of the mountain southwest of Wawarsing is a wide plateau which is traversed by the valley of Stony creek. Its surface is very irregular and low cliffs of the bare grit abound.

The grit in the higher portion of Shawagunk mountain nearly everywhere presents a basined surface. These basins are depressed an inch or two below the general level and are of various sizes and shapes. They usually contain pools of water and some sand and pebble detritus. They are mostly smooth and even polished and are distributed all over the mountain, but particularly on the western slope. With the polishing are associated lines of glacial scorings and striation which are conspicuous at nearly every locality. Julien* has recorded the direction of some of these striæ and scorings. The general direction is southwestward and the average depth is between one-sixteenth and one-eighth of an inch. In the vicinity of Sams point the most abundant scratches trend south 46° west and south 29° west.

* New York Academy of Sciences, Trans., vol. iii, pp. 22–29.

A few were observed somewhat more to the westward in direction, one-fourth inch in depth.

In the vicinity of lake Mohonk, about the hotel and on the northwestern slope, south 10° west is the general direction; on the southeastern side of the mountain and on the road to Alligerville, it is south 40° east; and at Sky Top, south 18° east. At lake Minnewaska the trend is south 10° west. There is but little foreign glacial drift on the summit of the range, so far as observed, but there is considerable in the adjoining valleys.

The origin and history of the lakes are not entirely clear, but they appear to be due to glacial agencies. The principal feature has been a local deepening and widening of a preëxistent valley, aided, at least in the case of lake Mohonk, by the presence of shales at the point now occupied by the lake. They do not appear to be due in great measure to damming by glacial or other débris or to dislocation.

Owing to its prominence the mountain has been long exposed to erosion. Originally the grit was overlain by a great mass of limestones and shales and the rocks of the Catskills, but these were removed far down into the Rondout valley at an early period. During the glacial epoch there was great erosion and the removal of great masses of the grit, which is now found in drift far to the southward. To the glaciation, too, probably is due the abruptness of Paltz point and other features of that sort. The grit also originally extended far to the eastward, but, owing to long-continued undermining by the removal of the soft, underlying shales, its front has receded to its present position. This recession is still actively in progress, and every year there fall great masses from the front of the mountain. One of the regions of weakness is Paltz point, for its base is exposed to erosion on several sides, and it will eventually disappear. Probably before it is gone the streams heading near its southern end will cut back through the shales at the head of lake Mohonk, and this beautiful body of water will be tapped. Of course this is all very remote, so far as human history goes, and artificial means will stay its progress in some measure, but it will all be accomplished in the near future, geologically speaking. Lakes Minnewaska and Awosting lie so far back from the front of the mountain that they will survive lake Mohonk by a very long time.